Cartilage versus partial ossicular replacement prosthesis in ossiculoplasty during cholesteatoma surgery

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Objective
This study aims at comparing cartilage ossiculoplasty by lever method with ossiculoplasty by partial ossicular replacement prosthesis during cholesteatoma surgery.
Patients and methods
This is a prospective study that was conducted on 36 cases having cholesteatoma; they were randomly divided into two groups of 18 in each group. In the first group (cartilage group), ossiculoplasty was performed with cartilage. In the second group (prosthetic group), ossiculoplasty was performed by partial ossicular replacement prosthesis. In both groups, eradication of the cholesteatoma was performed first at the same sitting of the ossiculoplasty by canal wall down tympanomastoidectomy with reconstruction of the posterior meatal wall at the same sitting.
Results
Within the follow-up period (1 year at least), the total rate of reported complications was relatively, but not significant, higher in the prosthesis group (50%) in comparison with the cartilage group (27.7%). There was a significant postoperative improvement in the air-bone gap in both groups; however, there was no significant difference between the two groups regarding improvement of the air-bone gap either 6 or 12 months after surgery.
Conclusion
Cartilage ossiculoplasty by lever method is an easy procedure for using an autogenous material in ossiculoplasty with no reaction, no extrusion, and also with acceptable hearing outcome.

Keywords:
canal wall down mastoidectomy, cartilage ossiculoplasty, lever method, partial ossicular replacement prosthesis

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Introduction

The main goal of the surgery of cholesteatoma is complete eradication of the disease, making the ear free of discharge and inflammation. The second goal of surgery is restoration of the function of the middle ear and the hearing mechanisms. The first goal can be achieved by either canal wall down mastoidectomy or canal wall up mastoidectomy with their inherent benefits and drawbacks. The advantages of both techniques can be, theoretically, gathered by partial removal of the posterior canal wall to facilitate eradication of cholesteatoma, followed by reconstruction of the canal wall for good anatomic and physiological results [1].

To achieve the second goal, restoration of the function of the middle ear and the hearing mechanisms, ossiculoplasty is usually needed to manage disruption of the ossicular chain that is usually present in cholesteatoma [2]. The most frequently seen ossicular problem is a defective or missing incus with an intact and mobile stapes and malleus, which represents 60% of all ossicular defects [3].

Reconstruction of the ossicular chain in patients with cholesteatoma has always been a challenge for the otologic surgeons; there is a great debate regarding the methods of ossiculoplasty in this situation. Cartilage ossiculoplasty was first described by Utech [4]. He introduced sculptured auricular cartilage as an interposition graft from the tympanic membrane to stapes head or footplate. Yamane *et al.* [5] described a new technique to reconstruct the ossicular chain with concha cartilage using a lever method to reduce the postoperative air-bone gap (ABG).

Over the past two to three decades, prostheses became more popular than autologous ossicles in case of middle ear reconstruction [6]. Usually, partial ossicular replacement prosthesis (PORP) is used when the stapes superstructure is intact, and a total ossicular

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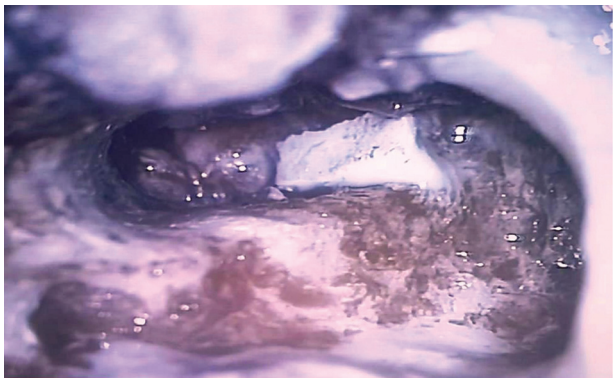
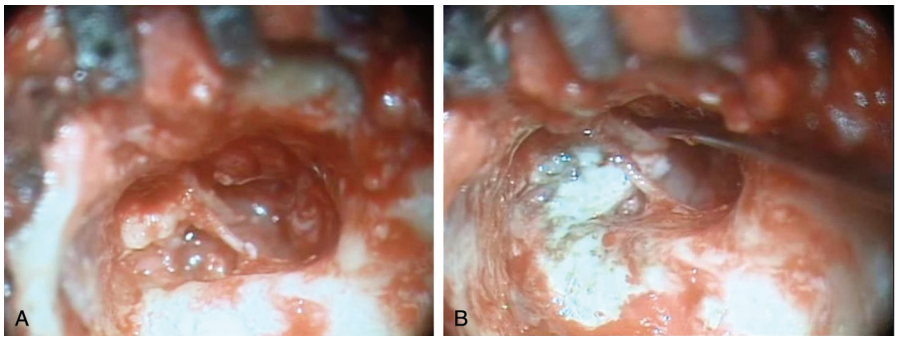
Figure 1



Left ear after canal wall down tympnaomastoidectomy with removed incus and malleus. The lever (rod of cartilage) is fixed from its upper end to the facial ridge, and the lower end is resting free in the middle ear.

Figure 2



(a) Right ear after canal wall down tympnaomastoidectomy with removed incus and intact malleus. (b) The lever (rod of cartilage) is fixed from its upper end to the facial ridge and the lower end is resting free in the middle ear below the handle of malleus.

replacement prosthesis is used when only a footplate remains [7].

In this study, we have compared cartilage ossiculoplasty by lever method with ossiculoplasty by PORP after cholesteatoma eradication by canal wall down tympanomastoidectomy and reconstruction of the posterior meatal wall at the same sitting.

Patients and methods

This is a prospective study that was conducted in our institute during the period from January 2014 to June 2015 on 36 cases who fulfilled the selection criteria, and they were randomly divided into two groups of 18 in each group. In the first group (cartilage group), ossiculoplasty was performed with cartilage. In the second group (prosthetic group), ossiculoplasty was performed by PORP. The follow-up period was at least 1 year.

All patients had chronic suppurative otitis media associated with the presence of cholesteatoma. All patients had documented conductive hearing loss with ABG more than 25 dB. All patients had detected ossicular discontinuity intraoperatively in the form of erosion of the long process of incus with intact stapes superstructure. All cases have been operated for eradication of the cholesteatoma at the same sitting of ossiculoplasty by canal wall down tympanomastoidectomy with reconstruction of the posterior meatal wall at the same sitting.

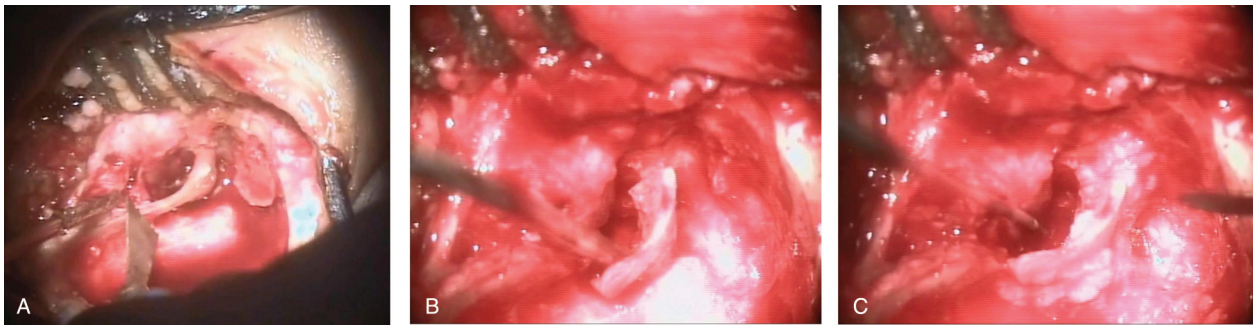
Patients with extensive cholesteatoma with intracranial complications or labyrinthine fistula, patients with erosion of the stapes superstructure, and patients with sensorineural hearing loss were excluded.

A written formal consent to participate in the study was signed by enrolled patients, and the study was approved by the Institutional Review Board at our institute.

Procedure

In the first group, the cartilage group, ossiculoplasty was performed with a cartilage as follows: through a postauricular incision and after eradication of the cholesteatoma by canal wall down tympano-masoidectomy, a conchal cartilage is harvested and

Figure 3



(a) Cutting of the lower border of posterior meatal wall by microsaw. (b) Repositioning the posterior meatal wall after eradication of cholesteatoma. (c) The final shape after stabilization of the posterior meatal wall with bone cement and/or bone Patte.

then a small rod sized about 6×3 mm is cut from this conchal cartilage. Then, a small pit in the harvested rod of cartilage is created and adjusted to the size of the head of the stapes using a Skeeter drill. This pit is created at midpoint of the cartilage rod and is put on the head of the stapes. The upper end of this rod is left rested on the facial ridge and the lower end is left free in the middle ear, but it must be separate from the tympanic ring to make a lever (Fig. 1). The handle of the malleus, if preset, should be over the lower end of the long arm of the rod. If there is erosion in the handle of the malleus, the graft is applied directly over the lever (Fig. 2). A drop of hydroxyapatite phosphate cement 'OtoMimix (Gyrus)' is put over the upper end of the rod of cartilage on the facial ridge for stabilization of the rod.

Then, the posterior meatal wall is reconstructed after adjustment of the rod of cartilage. This was performed by repositioning of the removed posterior meatal wall, which was cut at its upper and lower border by the microsaw. Bone patte is used for further stabilization of the posterior meatal wall; hydroxyapatite phosphate cements may be used to fix the posterior meatal wall if its position is not stable (Fig. 3).

In the second group, the prosthetic group, ossiculoplasty was performed by PORP after eradication of the cholesteatoma by canal wall down tympano-masoidectomy. The prosthesis was inserted connecting the head of the stapes to the tympanic membrane graft, and it was covered with a sliced cartilage graft to prevent direct contact of the prosthesis with the tympanic membrane preventing prosthesis extrusion. The prosthesis used in the study group was Kurz Bell prosthesis (Kurz Medical, Norcross, Georgia, USA). Reconstruction of the posterior meatal wall is performed by the same technique as described in the first group.

Postoperative follow-up

Intravascular antibiotic was given for 2 days, followed by oral antibiotics and oral decongestants for 5 days. Mastoid bandage, aural pack, and sutures were removed on the seventh day.

Patients were followed up weekly for 1 month. The hearing evaluation was made 3 months, 6 months, and 1 year after surgery. This evaluation was performed by pure tone average and speech recognition threshold. Otoendoscopic examination was performed also in the outpatient clinic in these periods.

Statistical methods

Results on continuous measurements are presented in mean and SD (minimum–maximum), and results on categorical measurements are presented in number (%).

Statistical analyses were calculated using the SPSS 17 statistical software for Windows (SPSS Inc., Chicago, Illinois, USA). Quantitative data were compared using a *t*-test with significance level set at *P* less than 0.05.

Results

The age of the patients ranged from 19 to 45 years, with a mean of 30.4±7.2 years. In all, 17 cases were male (eight in group A and nine in group B) and 19 cases were female (10 patients in group A and nine patients in group B). Right ear was operated in 14 cases (six patients in group A and eight patients in the group B). Left ear was operated in 22 cases (12 patients in group A and 10 patients in group B). All of the patients had eroded long process of the incus and intact stapes. The handle of malleus was lost during surgery in five patients (three patients in group A and two patients in group B) (Table 1).

Within the follow-up period (1 year at least), the following complications were reported: graft failure, prosthesis extrusion, postoperative retraction, recurrence of

Table 1 Demography and preoperative findings of both studied groups

	Total	Cartilage group	Prosthesis group	*P* value	Significance
Age (years)	30.4±7.2				
Male	17	8	9	1	NS
Female	19	10	9		
Right ear	14	6	8	0.7332	NS
Left ear	22	12	10		
Lost handle of malleus	5	3	2	1	NS

Table 2 Postoperative complications in both studied groups

Postoperative complications	Cartilage group	Prosthetic group	Total	*P*
Graft failure	2	4	6	0.6581
Prosthesis extrusion	0	2	2	0.4857
Postoperative retraction	1	1	2	1
Recurrence of cholesteatoma	1	2	3	1
Worsening of hearing	1	0	1	1
Total	5	9	14	0.3053

cholesteatoma, and worsening of hearing. Table 2 shows the incidence of those complications among both groups.

Table 3 shows the main value of the ABG of patients in the first (lever) group in the preoperative period and 6 and 12 months after surgery.

Table 4 shows the main value of the ABG of patients in the second (prosthetic) group in the preoperative period and 6 and 12 months after surgery.

These tables show significant postoperative improvement in the ABG in the cartilage group. In addition, there is postoperative improvement in the ABG in the prosthesis group, which was significant at 12 months after surgery but not significant at 6 months after surgery.

Tables 5–7 shows the statistic comparison between the ABG in both study groups either before surgery or 6 and 12 months after surgery.

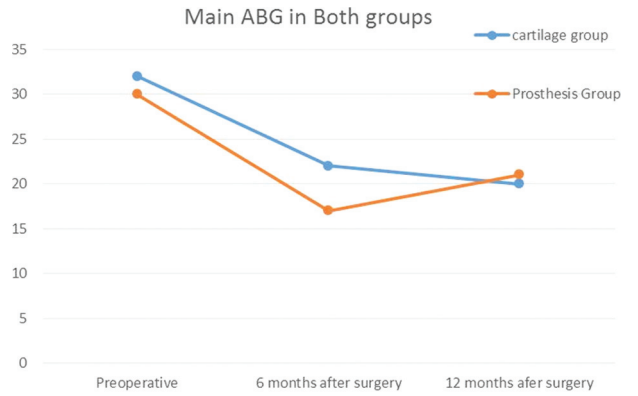
There is no significant difference between the two groups regarding improvement of the ABG either 6 or 12 months after surgery.

Fig. 4 summarizes the results of this study.

Discussion

In reporting results of ossiculoplasty, there is usually a difficulty in realistically assessing and comparing methods and case series because of the lack of standard reporting protocols [8]. In this series, we

Figure 4



Air-bone gap values of both studied groups.

have attempted to reduce the errors in reporting by comparing results with two different ossiculoplasty techniques performed by the same team of surgeons in the same situation – that is, after canal wall down tympanomastoidectomy with reconstruction of the posterior meatal wall with the presence of intact stapes super structures.

To remove cholesteatoma and reconstruct the posterior meatal wall, we used a technique similar to that of McElveen and Chung [9] who first described en bloc removal of the posterior bony canal wall with an oscillating microsaw. Next, after removal of cholesteatoma, the canal wall is replaced and secured with bone cement.

Ossiculoplasty has a great impact on hearing improvement after canal wall down tympanomastoidectomy; this was proven in a study conducted by Linstrom and colleagues on 24 patients with chronic suppurative otitis media who underwent tympanoplasty with mastoidectomy to evaluate preoperative and postoperative air conduction threshold. Ossicular reconstruction was performed in 14 patients. In the ossicular reconstruction group, the results revealed a significant improvement in the postoperative AC thresholds at 250, 1000, and 2000 Hz. [10].

Cartilage ossiculoplasty has very low graft failure or extrusion [11], but it has low sound conduction ability

Table 3 Paired *t*-test for comparison between preoperative and 3 and 6 months postoperative air-bone gap values of patients in the cartilage group

	Air-bone gaps (mean±SD)	Improvement (%)	*t* value	*P* value	Significance
Preoperative	30±6.1				
6 months postoperative	16.3±7.6	45.7	7.514	<0.001	S
12 months postoperative	21.3±6.4	29	7.0	<0.001	S

S, significant.

Table 4 Paired *t*-test for comparison between preoperative and 3 and 6 months postoperative air-bone gap values of patients in the prosthesis group

	Air-bone gaps (mean±SD)	Improvement (%)	*t* value	*P* value	Significance
Preoperative	31.9±13.1				
6 months postoperative	22.5±9.3	29.5	2.311	0.054	NS
12 months postoperative	20±7.1	37.3	2.815	0.026	S

S, significant.

Table 5 *t*-Test for comparison of preoperative air-bone gap values of both studied groups

	Air-bone gaps (mean±SD)	*t* value	*P* value	Significance
Cartilage group	30±6.1	0.351	0.731	NS
Prosthesis group	31.9±13.1			

Table 6 *t*-Test for comparison of 6 months postoperative air-bone gap values of both studied groups

	Air-bone gaps (mean±SD)	*t*	*P* value	Significance
Cartilage group	16.3±7.6	1.57	0.139	NS
Prosthesis group	22.5±9.3			

Table 7 *t*-Test for comparison of 12 months postoperative air-bone gap values of both studied groups

	Air-bone gaps (mean±SD)	*t*	*P* value	Significance
Cartilage group	21.3±6.4	0.37	0.717	NS
Prosthesis group	20±7.1			

[12]. However, we used a technique for cartilage ossiculoplasty that has been first described by Yamane *et al.* [5]; this technique depends on the elasticity of the cartilage to make a lever action during sound transmission by fixing one end of the cartilage to the facial ridge and leaving the other end free, and the head of the stapes is between the two ends. The cartilage can generate enhanced force by this lever mechanism at the fulcrum of the head of the stapes. The cortical bone is rigid; therefore, they cannot flex when they are fixed with the facial ridge on one edge, but cartilage can. We used cartilage from the cymba concha, from which a sufficient amount of cartilage can be obtained for making the lever; also, it can be sliced for grafting the tympanic membrane.

In our series using cartilage ossiculoplasty by lever method, we achieved significant improvement in ABG either 6 or 12 months after surgery. The main ABG at 6 months after surgery was 16.3±7.6 and the main ABG at 12 months after surgery was 21.3±6.4.

In addition, we had no extrusion in the cartilage group. Chole and Kim [11] in a series of 187 cases of ossiculoplasty performed with cartilage prostheses reported no extrusions.

Many artificial materials are available for ossiculoplasty; however, in our series we used the titanium prosthesis, as titanium has a greater ability to transmit sound more than other prosthetic materials such as hydroxyapatite [13]. Furthermore, the slim profile of titanium prostheses and open head design facilitates intra-operative placement [6]. However, titanium implants need to be covered with a cartilage inter-position graft to prevent extrusion [14]. Our extrusion rate was relatively high at 10% at 6 months in comparison with other series in the literature, which quote low extrusion rates – for example, there was no extrusion after titanium ossiculoplasty in 124 ears by Wang *et al.* [15] This may be because of the fact that all of our cases are ossiculoplasty in the same sitting of the primary surgery for cholesteatoma.

In addition, we used the titanium PORP, which is reported to have more favorable results than total ossicular replacement prosthesis [16]; this may be because of the fact that the presence of a stapes superstructure is an important prognostic factor in predicting good postoperative hearing outcomes [17].

In our series, we achieved significant improvement in ABG 12 months after surgery. The ABG was 22.5 dB± 9.25 6 months after surgery and 20 dB±7.07 12 months after surgery

By comparing the results of both groups, we found that the ABG improvement between the two groups is not

significant; however, the complications were significantly lower in the cartilage group because of less risks of extrusion. In addition, we found that the ABG 6 months after surgery is better than ABG 12 months after surgery in the prosthetic group, and the reverse was found in the cartilage group. This finding may be explained by cartilage resorption; however, this needs to be confirmed by longer-term follow-up studies.

Conclusion

Cartilage ossiculoplasty by lever method is an easy procedure for using an autogenous material in ossiculoplasty with no reaction, no extrusion, and also with acceptable hearing outcome.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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